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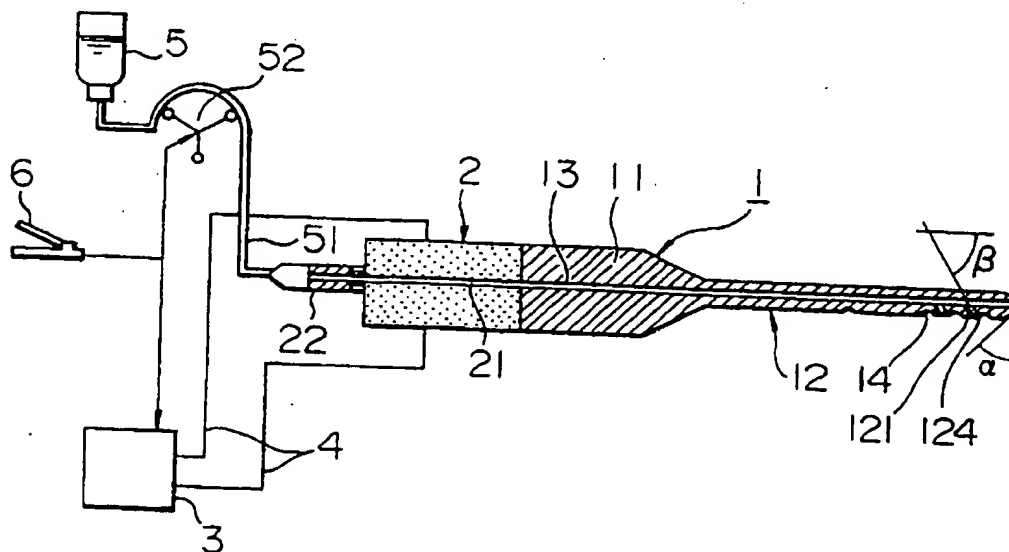
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(54) **Surgical ultrasonic horn.**

(57) A surgical ultrasonic horn (1) used in a surgical operation comprises a horn body (11) and an end plate portion (12). Cutting portions (121) are provided on an edge and an end of the end portion. A passage (21) for irrigation solution extends in the horn body and the end plate portion. At least one bore (124) opens at the cutting portions by a jet angle ( $\beta$ ) of 5° to 90° in respect of a plane of the end plate portion. The irrigation solution passage communicates with the bore, thereby the irrigation solution is sprayed therethrough.

**FIG. 2**



**EP 0 456 470 A1**

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EP 0 456 470 A1

2

## FIELD OF THE INVENTION AND RELATED ART STATEMENT

The present invention relates to a surgical ultrasonic horn. These horns are generally used in cutting and separating of the living tissue, e.g. cartilaginous tissue or bone.

A surgical knife has been widely used for this purpose. However, the surgical knife is inferior in cutting efficiency. Therefore, it prolongs an operating time to impose serious exertion on the operator. Further, the operator is required to operate it with a higher cutting technique.

Some surgical tools using an ultrasonic have been proposed. For example, in the surgical tool disclosed in Japanese Patent Examined Publication No. 47-39197, an ultrasonic oscillating element pounds at a flat end thereof a surface of the tissue. Therefore, the part of tissue pounded is crushed and emulsified and then removed outside. However, such surgical tool isn't appropriate for cutting and separating of tissue.

Further, another surgical tool uses an ultrasonic oscillator provided at a distal end thereof with a saw portion. In operation thereof, the ultrasonic oscillation generates frictional heat between the distal end and the tissue to be cut to raise the temperature at that point to some hundreds °C. Accordingly, the cut part of tissue is carbonized, and the distal end of the oscillator may deteriorate and then may be broken.

## OBJECT AND SUMMARY OF THE INVENTION

Accordingly, an object of the present invention is to provide a surgical tool using an ultrasonic which is adapted to cut and separate tissue and is capable to restrict the generation of frictional heat.

The function and the advantages of the present invention will be apparent from the following explanation of the preferred embodiments described with referring to the accompanying drawings attached hereto.

## BRIEF DESCRIPTION OF THE DRAWINGS

Fig. 1 is an enlarged fragmentary perspective view showing an ultrasonic horn according to a first embodiment of the present invention;

Fig. 2 is a surgical operating apparatus using the horn shown in Fig. 1;

Figs. 3 to 7C are fragmentary perspective views showing a second to a seventh embodiments of the present invention, respectively;

Figs. 8 to 10 are fragmentary perspective views showing horns modified from one shown in Fig. 7;

Figs. 11A to 17A are front views showing the embodiments of different shapes of the cutting portion, respectively; and

Figs. 11B to 17B are sectional views of the embodiments shown in Figs. 11A to 17A, respectively.

## DETAILED DESCRIPTION OF PREFERRED EMBODIMENTS

An ultrasonic horn 1 shown in Fig. 1 is connected to an ultrasonic oscillation source 2 so as to cooperate therewith. The ultrasonic oscillation source 2 is electrically connected to an ultrasonic oscillator 3 through cables 4.

The ultrasonic oscillation source 2 is provided at an interior thereof with a through bore 21 through which an irrigation solution flows. The bore 21 is communicated at one end thereof to a bin 5 containing therein physiological saline through a tube 51 and a nipple 22 mounted to the ultrasonic oscillation source 2. A roller pump 52 is disposed in a mid portion of the tube 51 so as to pump the physiological saline.

A foot switch 6 synchronizes the ultrasonic oscillator 3 and the roller pump 52.

As shown in Fig. 1, the ultrasonic horn 1 includes a horn body 11 connected at one end thereof to the ultrasonic oscillator 3 and an end portion 12 connected at one end thereof to the other end of the horn body through intermediate portion. They are integrated with each other. Cutting portions 121 and 123 are provided at one edge and an end of the end portion 12, respectively. The horn 1 is provided at an interior thereof with a passage 13 through which the irrigation solution flows. The passage 13 is communicated at one end thereof with the bore 21 and the other end thereof is opened at the end of the end portion 12. The cutting portion 121 presents an elongate plate like shape. In order to improve the cutting efficiency, the cutting portion 123 is rounded and is tapered by a slant angle  $\alpha$  ( $\alpha \geq 45^\circ$ ) in respect of the oscillation direction. A plurality of recesses 14 are provided on the cutting portion 121. Further, a plurality of jet bores 124 for irrigation solution are provided on the cutting portion 121. The jet bore 124 is opened at the cutting portion 121 by a jet angle  $\beta$  ( $\beta \geq 5^\circ$ ) in respect of an extending direction of the passage 13.

Next, an operation of the above explained apparatus will be described hereinafter.

At first, the foot switch is closed to operate the ultrasonic oscillator 3 and the roller pump 52. The roller pump 52 supplies physiological saline from the bin 5 to the passage 13 through the tube 51, the nipple 22 and the through bore 21 of the ultrasonic oscillation source 2. Simultaneously the ultrasonic oscillator 3 drives the ultrasonic oscillation source 2 to mechanically oscillate the horn 1. According this, the cutting portions 121 and 123 cut and separate the tissue. In this occasion, physiological saline is sprayed through the jet bores 124 towards on the tissue portion to be cut. The physiological saline suppresses the raising of temperature due to the frictional heat in the cutting

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EP 0 456 470 A1

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portions 121, 123 and the tissue portion to be cut, thereby preventing the cutting portions 121 and 123 from being deteriorated and the tissue portion to be cut from being carbonized. In case that the irrigation solution of 10°C to 25°C is sprayed, the temperature of the tissue portion to be cut is maintained at about 15°C to about 30°C. Further, the jets of physiological saline can remove fine particles of the cut tissue from the surface of the tissue to expose new tissue surface to the operator. According this, the operation efficiency is further improved. Further, the jets of physiological saline stimulate the osteoblast on the bone and then promote the recovery of the cut portion.

In order to obtain a suitable jet of physiological saline, it is preferable that diameters of the jet bores 124 and the opening of the end of the end portion 12 are equal or smaller than a diameter of the passage 13. In case that the jets of physiological saline may restrict a visual field of the operation, it would be preferable to prevent the passage 13 from extending to the end of the end portion 12.

In this embodiment, the recess 14 has a semi-spherical shape. However, another shapes may be applicable according to the circumstances. A radius of the recess 14 is between 0.3 mm and 2.5 mm. A depth is between 0.1 mm and 2 mm, preferably between 0.5 mm and 1.5 mm. A pitch between the recesses is between 1.5 mm and 7 mm, preferably between 2 mm and 3 mm. Due to the semi-spherical recesses, the cutting portion 121 isn't broken even though the ultrasonic oscillation of a higher amplitude of 100  $\mu$ m to 300  $\mu$ m is applied. Further, since the contact resistance between the bone and the cutting portions is reduced, the cutting efficiency is improved by 20% to 30% as compared with the one without recesses.

It can be possible that the cutting portion 123 is defined by linear boundaries (Fig. 4). The slant angle  $\alpha$  is 45° or more, preferably 60° to 90°. The thickness of the cutting portion 123 is between 0.1 mm and 7.0 mm, preferably between 0.2 mm and 1.5 mm.

A contour of the intermediate portion between the horn body 11 and the end portion 12 may be an arc, a catenary, exponential, or Fourier curve, instead of the flat tapered one shown in Fig. 2.

The material of the horn is preferably titanium alloy, or stainless alloy, or a composition of titanium alloy and stainless alloy. It may be possible to apply a coating or abrasion resistance process to the cutting portions.

According to this embodiment, on the cutting and separating of the bone, due to the shape of the cutting portions specified above, the cutting portions smoothly enters from the surface of the bone to an interior thereof by means of the mechanical ultrasonic oscillation when it contacts slightly to the bone. Therefore, the scattering against the operator is suppressed, thereby being capable of operating with higher precision. The elastic tissue of the bone, e.g. periosteum is never damaged by the horn 1 due to the characteristics of the ultrasonic.

teum is never damaged by the horn 1 due to the characteristics of the ultrasonic.

The embodiment shown in Fig. 5 is suitable to the cutting operation in case that the visual field is restricted. The end portion 12 is bent by an angle  $\gamma$  in respect of an axis of the horn body 11. The angle  $\gamma$  is preferably between 10° and 30°.

In the embodiments shown in Figs. 6A and 6B, the end portion is detachably screw-mounted to the horn body. In this case, the end portion must be so mounted to the horn body that the axis of the horn body extends within a plane including the cutting portion.

In the embodiment shown in Fig. 7, the end portion 12 is provided at opposite edges thereof with a first and a second cutting portions 121, 122, and at end thereof with a third cutting portion 123. The irrigation solution passage 13 doesn't extend to the end of the end portion though it can open at the end of the end portion. A pair of irrigation solution jet bores 125 and 126 open at a proximal portion of the end portion 12 by the jet angle  $\beta$  ( $\beta \geq 5^\circ$ ) in respect of the extending direction of the irrigation solution passage 13, respectively (Fig. 7A). A plurality of another jet bores 127 open at the cutting edges 121 and 122, respectively (Figs. 7B and 7C). There may be some modifications as shown in Figs. 8 to 10. Namely, the end portion 12 is bent by an angle  $\gamma$  in respect of the axis of the horn body 11 and/or is detachably screw-mounted to the horn body 11.

The cutting portions of the embodiments shown in Figs. 11A to 17B are different from one another. The cutting portions 121 and 122 extend parallel to the direction of the ultrasonic oscillation. On the contrary, the cutting portion 123 has linear boundaries which extend so as to cross the oscillation direction, namely extend in a direction which crosses the oscillation direction by an angle  $\alpha$  not zero. The cutting portion 123 may have an arc contour.

## Claims

1. A surgical ultrasonic horn comprising:
  - a horn body connected, in use, at one end thereof to an ultrasonic oscillation source;
  - an end portion extending from the other end of said horn body, said portion being provided at an edge and an end thereof with plate-like cutting portions;
  - passage means extending in said horn body and said end portion, through which, in use, irrigation solution flows; and
  - at least one bore through which said irrigation solution is sprayed in use, said bore communicating with said passage and opening at said cutting portion by a jet angle of 5° to 90° in respect of an axis of said horn body.

5

EP 0 456 470 A1

6

2. A horn according to claim 1, wherein another bore, through which, in use, said irrigation solution is sprayed, is provided at a side of said end portion.
3. A horn according to claim 1, wherein said passage opens at said end of said end portion.
4. A horn according to claim 1 or claim 3, wherein said cutting portion is provided with at least one recess.
5. A horn according to claim 1, wherein said cutting portions are provided on opposite edges of said end portion.
6. A horn according to claim 3, wherein said cutting portions are provided on opposite edges of said end plate portion.
7. A horn according to claim 1 or claim 6, wherein one of said opposite edges is provided with a plurality of cutting portions.
8. A horn according to claim 1 or claim 2, wherein said end portion is bent in respect of an axis of said horn body by an angle not greater than 90°.
9. A horn according to claim 1 or claim 2, wherein said cutting portion provided at the edge of said end portion extends parallel to an oscillation direction.
10. A horn according to claim 1 or claim 2 or claim 9, wherein said cutting portion provided at the end of said end portion is rounded.
11. A horn according to claim 1 or claim 2 or claim 9, wherein said cutting portion provided at the end of said end portion is tapered by an angle between 45° and 90°.

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EP 0 456 470 A1

FIG. 1

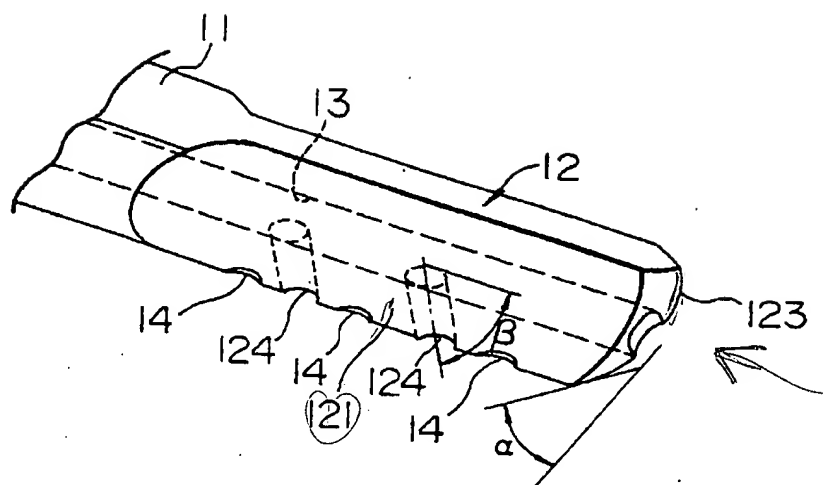


FIG. 2

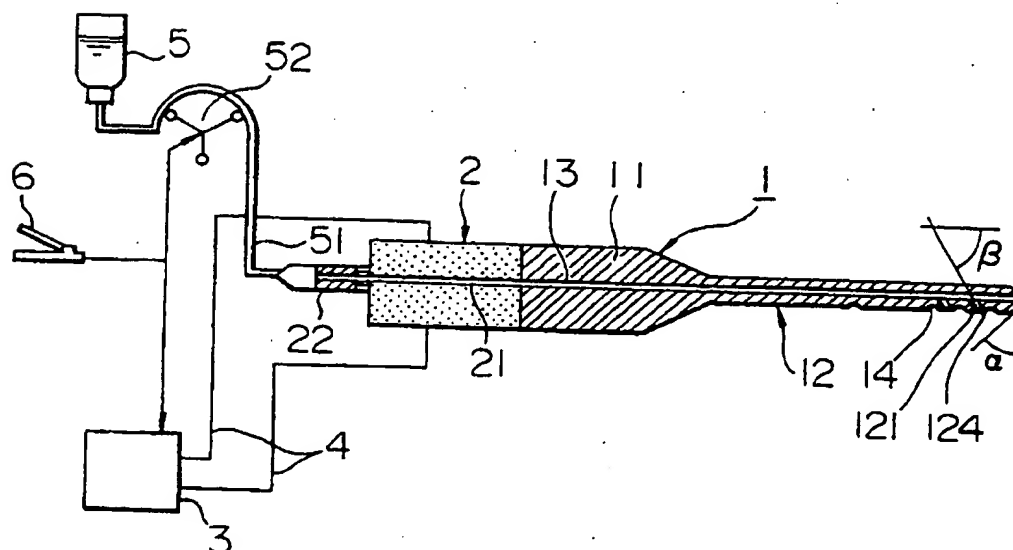


FIG. 3

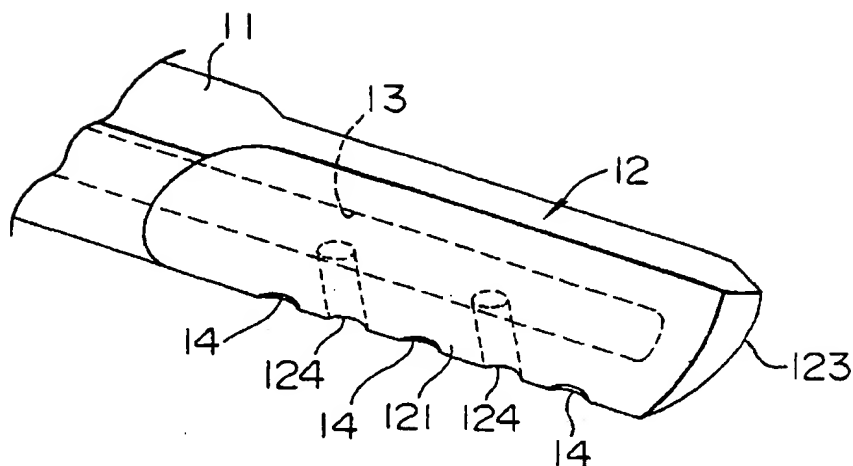
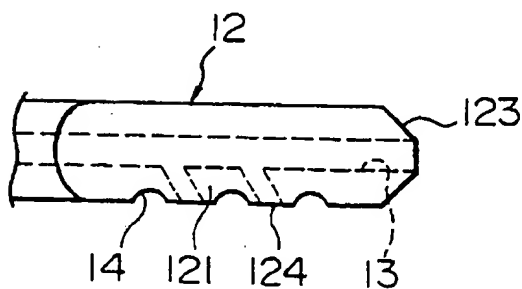


FIG. 4



EP 0 456 470 A1

FIG. 5

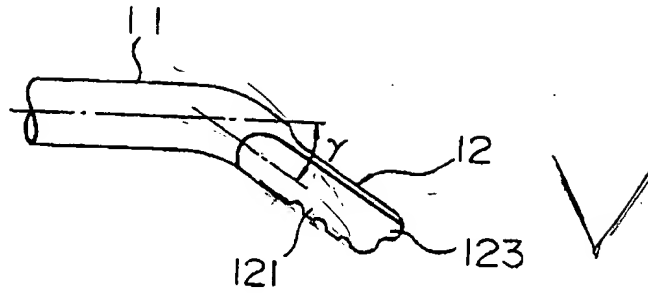


FIG. 6A

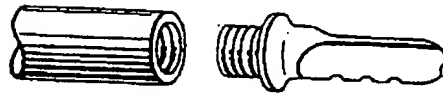
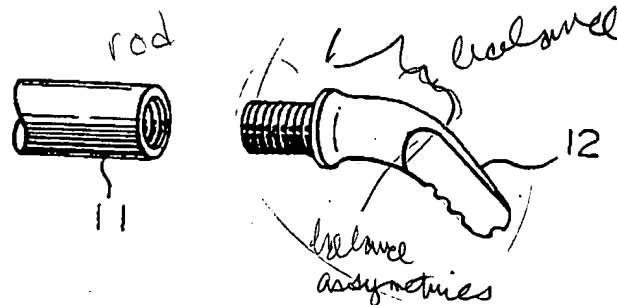


FIG. 6B



EP 0 456 470 A1

FIG. 7

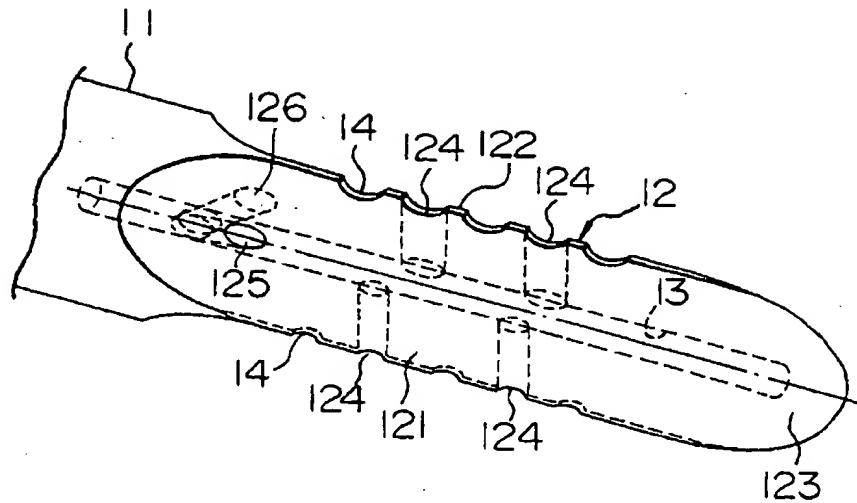


FIG. 7A

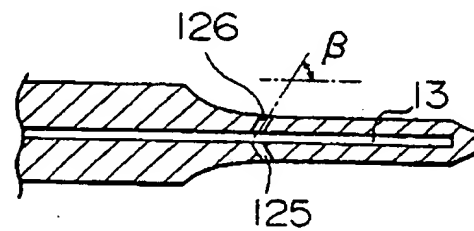


FIG. 7B

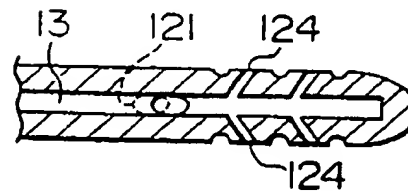
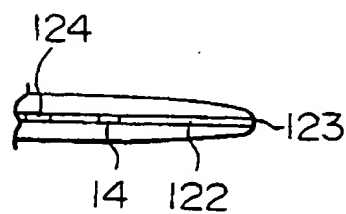


FIG. 7C





EP 0 456 470 A1

FIG. 8

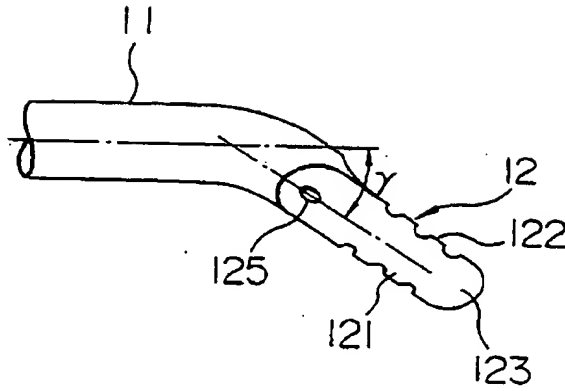


FIG. 9

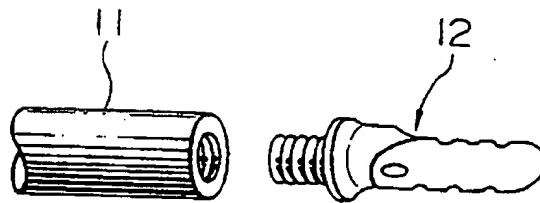
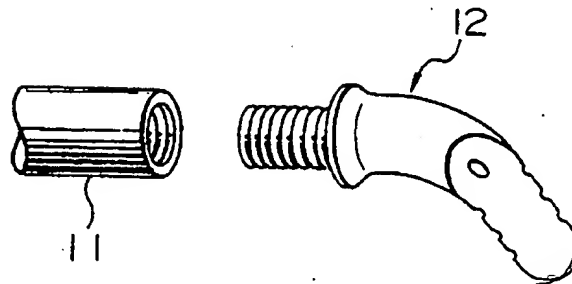


FIG. 10



EP 0 456 470 A1

FIG. 14A

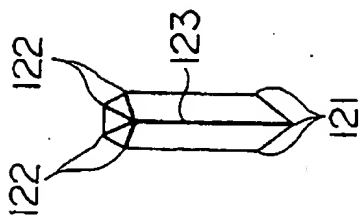


FIG. 13A

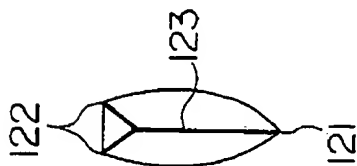


FIG. 12A

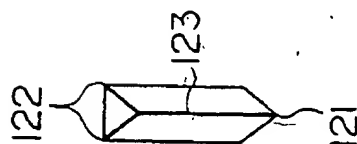


FIG. 11A

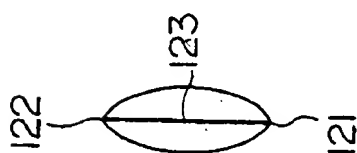


FIG. 14B

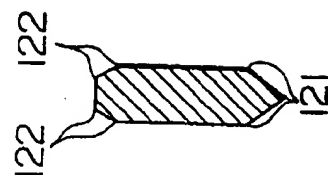


FIG. 13B



FIG. 12B



FIG. 11B



EP 0 456 470 A1

FIG. 17A

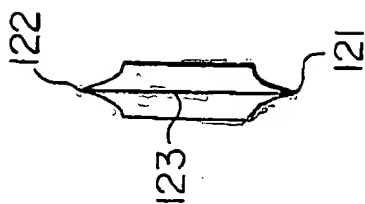


FIG. 17B



FIG. 16A

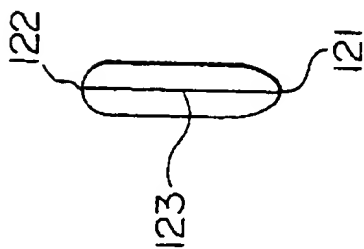


FIG. 16B



FIG. 15A

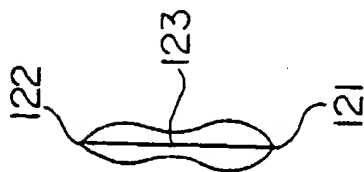


FIG. 15B



EP 0 456 470 A1

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## EUROPEAN SEARCH REPORT

Application Number

EP 91 30 4121

DOCUMENTS CONSIDERED TO BE RELEVANT			
Category	Citation of document with indication, where appropriate, of relevant passages	Relevant to claim	CLASSIFICATION OF THE APPLICATION (Int. Cl.5)
Y	GB-A-1 457 544 (MOSKOVSKOE ORDENA LENINA I ORDENA TRUDOVOGO KRASNOGO ZNAMENI VYSSHEE) * page 3, line 104 - page 4, line 22; figures 1,4,5 *	1-11	A61B17/32
Y	US-A-3 526 219 (BALAMUTH) * abstract * * column 3, line 9 - column 3, line 19; figure 5 *	1-11	
A	EP-A-139 753 (SUMITOMO) * page 17, line 15 - page 18, line 8; figure 13 *	3	
A	US-A-3 086 288 (BALAMUTH) * column 4, line 72 - column 4, line 75; figure 4 * * column 5, line 3 - column 5, line 6; figure 6 *	8,9,11	
			TECHNICAL FIELDS SEARCHED (Int. Cl.5)
			A61B A61F
The present search report has been drawn up for all claims			
Place of search THE HAGUE		Date of completion of the search 19 AUGUST 1991	Examiner MOERS R.
CATEGORY OF CITED DOCUMENTS X : particularly relevant if taken alone Y : particularly relevant if combined with another document of the same category A : technological background O : non-written disclosure F : intermediate document T : theory or principle underlying the invention E : earlier patent document, not published on, or after the filing date D : document cited in the application L : document cited for other reasons & : member of the same patent family, corresponding document			

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EP 0 456 470 A1

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## EUROPEAN SEARCH REPORT

Application Number

EP 91 30 4121

DOCUMENTS CONSIDERED TO BE RELEVANT			
Category	Citation of document with indication, where appropriate, of relevant passages	Relevant to claim	CLASSIFICATION OF THE APPLICATION (Int. Cl.5)
Y	GB-A-1 457 544 (MOSKOVSKOE ORDENA LENINA I ORDENA TRUDOVOGO KRASNOGO ZNAMENI VYSSHEE) * page 3, line 104 - page 4, line 22; figures 1,4,5 *	1-11	A61B17/32
Y	US-A-3 526 219 (BALAMUTH) * abstract * * column 3, line 9 - column 3, line 19; figure 5 *	1-11	
A	EP-A-139 753 (SUMITOMO) * page 17, line 15 - page 18, line 8; figure 13 *	3	
A	US-A-3 086 288 (BALAMUTH) * column 4, line 72 - column 4, line 75; figure 4 * * column 5, line 3 - column 5, line 6; figure 6 *	8,9,11	
			TECHNICAL FIELDS SEARCHED (Int. Cl.5)
			A61B A61F
The present search report has been drawn up for all claims			
Place of search THE HAGUE		Date of completion of the search 19 AUGUST 1991	Examiner MOERS R.
CATEGORY OF CITED DOCUMENTS X : particularly relevant if taken alone Y : particularly relevant if combined with another document of the same category A : technological background O : non-written disclosure F : intermediate document T : theory or principle underlying the invention E : earlier patent document, but published on, or after the filing date D : document cited in the application L : document cited for other reasons & : member of the same patent family, corresponding document			

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